Fiscal Year:	FY 2010	**Task Last Updated:**	FY 07/01/2010
PI Name:	Sebok, Angelia M.S.		
Project Title:	Space Human Factors and Habitability MIDAS-FAST: Development and Validation of a Tool to Support Function Allocation		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **SHFH**:Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	(1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	80301-2560	**Congressional District:**	2
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2008 Crew Health NNJ08ZSA002N
Start Date:	09/01/2009	**End Date:**	08/31/2012
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:	1	**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:	There are no PI or Co-I changes to report. One software developer specifically identified in the proposal, Shelly Scott-Nash, is now serving as an advisor instead of her originally-proposed role of software developer and MIDAS modeler. Mark Brehon and Dr. Marc Gacy will provide software development and MIDAS modeling expertise.		
COI Name (Institution):	Sarter, Nadine (University of Michigan) Gore, Brian (San Jose State University Research Foundation)		
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Performance Goal No.:			
Performance Goal Text:			

Task Description:	This proposal describes a plan to develop and validate a computer-based tool to allow researchers to evaluate various function allocation strategies in space missions. The purpose of this tool is to enable researchers to evaluate novel human-automation systems early in the design process. The tool will leverage the Man-Machine Integration Design and Analysis System (MIDAS, developed for NASA Ames), and provide the MIDAS-FAST (Function Allocation Simulation Tool). In this project, the team will develop a research-based module of human-automation interaction. The team will develop human performance models of scenarios of interest. These models will be based on task analyses performed in cooperation with subject matter experts (SMEs). Various validation studies will be performed throughout this project. The team will validate the task analyses by talk-through sessions with SMEs. Human performance model and human-automation interaction module predictions will be validated in empirical, human-in-the-loop studies. Results of the validations will be used to refine the models. One particular focus of the project is on developing a prototype tool that is both usable and useful for researchers, allowing them to easily modify scenarios and evaluate different potential automation conditions. This tool will provide for data entry screens that guide the user through the process of building a scenario. It will allow the researchers to specify numerous relevant factors, e.g., operators, tasks, environmental conditions, and function allocation strategy. It will offer a visualization capability that provides a virtual video of the scenario, showing operators interacting with equipment and each other. The output of the model run will include, in addition to the video file, parameters of interest such as situation awareness, workload, time to initiate tasks, time to complete tasks, and task accuracy.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The research will provide (and empirically validate) a tool, MIDAS-FAST, to evaluate the effects of function allocation strategies and automation reliability on human performance in robotic tasks. While the tool is being developed specifically for space robotic tasks, we anticipate that the model predictions will also apply to Earth-based robotic tasks. MIDAS-FAST will allow analysts (e.g., researchers, system developers, and concept developers) to enter data regarding the proposed robotic system, allocation of tasks, and the potential for automation failures. The tool will use a variety of sub-models, called modules, to evaluate particular aspects of operator performance (e.g., focus of visual attention, situation awareness, disorientation and performance decrements due to control-response incompatibilities). The tool will then provide feedback on predicted operator performance (e.g., time to complete task; error such as reversals, collisions, rule violations), workload, situation awareness. This will help analysts evaluate potential robotic systems in terms of their predicted effects on operator performance. Model predictions will be evaluated and refined with data collected during two human in the loop studies.
Task Progress:	The NASA Human Research Program project, MIDAS-FAST: A Tool for Evaluating Function Allocation, is nearing completion of the first year of research. The main overall objective of the proposed research is to develop tools and empirically-based guidelines that support designers in developing new technologies. Specifically, the products from this research will help designers and mission planners (a) anticipate and avoid potential problems in function allocation strategies in system design before new systems are introduced, and therefore (b) assure that these systems and their function allocation strategies can be implemented seamlessly and in a way to minimize transient or longer-term impacts on performance in space exploration missions. The proposed work contributes to the Program Requirements Document (PRD) Risk Associated with Poor Task Design (20.0 – D X I), and specifically addresses Integrated Research Plan (IRP) Gap Space Human Factors Engineering SHFE4: Guidelines are needed for appropriate task automation as well as for effective allocations of tasks between humans and automation to increase performance, efficiency, and safety. To help NASA achieve these objectives, Alion Science and Technology, together with Dr. Christopher Wickens, the University of Michigan, the San Jose State University Research Foundation, and Dr. Thomas Jones, proposed to develop and empirically validate the MIDAS-FAST simulation tool. MIDAS-FAST is based on human-performance models, together with a simulation environment, to allow system designers and concept developers evaluate the effects of function allocation strategies, varying types of automation (e.g., fixed, adaptive, and adaptable automation), and automation reliability on operator and system performance. In developing this tool, our plan of work consists of six key tasks, identified below. The following paragraphs identify the task, describe the progress to date, and (where appropriate) briefly outline the plan for further research. 1.1 Identify an appropriate domain and simulation environment Progress: This task is complete. The team, with input from NASA personnel, has identified the space robotics domain. We have obtained from NASA the necessary set of software tools to simulate robotics tasks, in particular, the Basic Operational Robotics Instructional System (BORIS). We have installed these tools at Alion and University of Michigan. We are currently familiarizing ourselves with their capabilities by working with the tools and attending the NASA General Robotics Training (GRT). The BORIS simulation at Alion will be integrated with the MIDAS human performance model and other performance modules, as described in other tasks below. The simulation at the University of Michigan will provide the task environment for the human in the loop simulation studies. 1.2 Conduct a literature review of human automation interaction Progress: This task is currently ongoing. An extensive literature review has been conducted: 1) to assess the effects of automation at varying stages (i.e., information acquisition, information analysis and integration, choosing and deciding, and executing an action) and levels (i.e., high, moderate and low degrees of automation) on operator performance, 2) to identify the effects of unreliable automation on performance, and 3) to evaluate context sensitive (adaptive and adaptable) automation. The “stages and levels” and “reliability” aspects of the literature review have been further refined to identify and extract the data that are relevant for module development. For next year, the effects of context-sensitive automation will be evaluated for a possible meta analysis, and the literature review will be summarized as a report. Relevant guidelines will be extracted and provided as a document. 1.3 Develop and validate modules of human performance Progress: This task is currently ongoing. We have identified a number of relevant modules to include in MIDAS-FAST. Modules are reusable computational models that predict specific aspects of human performance. These will interact with the MIDAS human performance model to predict operator behavior and outcomes for the user-specified conditions. We will, when possible, leverage existing models developed under other NASA efforts. These include the Salience, Expectancy, Effort, and Value (SEEV) model of visual attention, and the Frame of Reference Transformation (FORT) model of human error due to control action – robotic arm movement incompatibility in robotic tasks. These are being

evaluated to customize them for MIDAS-FAST. Other modules under development include operator performance in different stages and levels of automation, in varying conditions of automation reliability, and in different conditions of context-sensitive automation.

1.4 Build and verify human performance models

Progress: This task is currently ongoing. The team is evaluating the robotic task domain, and identifying how this differs from aviation. MIDAS has been developed for aviation, so it will need to be updated to accommodate the differences between domains that affect operator cognition and performance. For example, aviation MIDAS models pilots scanning discrete displays, and performing aviation, navigation, communication, and systems monitoring tasks. In robotics applications, MIDAS will model operators planning tasks, configuring displays, initiating movements, monitoring progress, and scanning displays. MIDAS modeling efforts will focus on progressively more detailed issues as the team identifies relevant scenarios and automation effects.

1.5 Plan, conduct, and evaluate empirical studies Progress: This task is currently ongoing. Both Alion and the University of Michigan (UM) team members are attending the NASA GRT course this summer to become knowledgeable about the domain and proficient in the domain tasks. Once the UM team members have attended this training (late July), conducted additional interviews with instructors and astronauts, and completed cognitive task analyses of robotic missions, we will begin development of scenarios for our two planned simulation studies and model evaluations. In preparation for those studies, we have also been familiarizing ourselves with the capabilities of the BORIS simulation tool. We have developed a stages and levels table to identify relevant automation conditions in the robotics domain, and we have identified a number of potential automation situations and possible failures.

Based on observations made by Alion team members during their recent training at NASA, we have reconsidered the requirements for participants for both simulation studies. The robotics tasks are not simple and can not adequately be taught in a simple 2-4 hour session. Therefore, we will need to identify and ensure access to appropriate personnel for even the initial experiment. Students in fields such as robotics and aeronautics will likely be asked to participate. For the final experiment, we are currently investigating the possibilities (advantages, disadvantages, availability) of having astronauts, general robotic training instructors, or other skilled personnel serve as participants. One continual challenge with this project is keeping the focus on issues that are relevant in actual robotic applications, and not simply BORIS-specific concerns.

1.6 Integrate the software tools to develop MIDAS-FAST Progress: This task is currently ongoing. As part of setting up BORIS and the related software (TRICK, the simulation environment, and EDGE, the graphic visualization), we have been familiarizing ourselves with the structure of these tools. We have identified how to collect data regarding operator rate selection, joystick movements, and the grapple trigger. We have also verified that it is possible to use a Microsoft Windows C# program to implement control actions in BORIS (running on Linux). This demonstration is the first step in connecting the MIDAS model (written in C#) to BORIS. Further work will include identifying the simulation data to collect, developing the capabilities to store this data, and integrating MIDAS with BORIS.

Bibliography Type:	Description: (Last Updated: 09/07/2020)
Articles in Peer-reviewed Journals	Wickens CD, Li H, Santamaria A, Sebok A, Sarter N. "Stages and levels of automation: An integrated meta-analysis." Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2010 Sep;54(4):389-93. http://dx.doi.org/10.1177/154193121005400425 , Sep-2010